Biological Evaluation
R2-03-06

Biological Evaluation of Insect and Disease Conditions in Teal Lake Campground

March 2003

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Biological Evaluation R2-03-06
Introduction

On August 14, 2002 representatives of the Lakewood Service Center and the Parks Ranger District of the Routt National Forest met to discuss forest health issues in the Teal Lake Campground. The purpose of the visit was to provide technical advice and assistance with regard to management actions that could be taken to improve stand conditions in the campground while at the same time addressing forest health concerns. In attendance were: Jeff Witcosky LSC Leader, Kelly Sullivan LSC Pathologist, Dave Johnson retired LSC Leader, Meg Halford LSC Biological Technician, and Mark Westfahl Parks Ranger District Forester. We had a brief meeting in the field with other forest representatives including Carl Maas, Ken Belcher, Tina Lanier, Chuck Oliver, and Mary Peterson.

Teal Lake Campground is adjacent to the southeast corner of the Mount Zirkel Wilderness Area (T7N, R82W, S9). The area is just below 9000 feet in elevation and is composed primarily of lodgepole pine (*Pinus contorta* Dougl. & Loud.) and subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) with occasional scattered aspen (*Populus tremuloides* Michx.) and Engelmann spruce (*Picea engelmannii* Parry ex Engelm.). The recreation area at Teal Lake consists of a day-use area with a boat launch and the campground itself with 17 camping units and a group area. The campground is approximately 12 acres in size. The stands within the campground are dense and fairly mature, with an estimated stand age of 80-100 years old (based on stand exam information from nearby stands) (Mark Westfahl, personnel communication). Historically, stand replacing fires have occurred at 200 year intervals in the Teal Lake area (Sam Duerkson, personal communication). This fire regime is characterized as being in "Condition Class 1" meaning that the current fire regime is within the historic range of variability and the risk of losing key ecosystem components is low. The last major disturbance to stands within Teal Lake Campground was approximately 80-100 years ago, based on stand age.

Teal Lake Campground was built in 1990. In 1994 the district began doing yearly hazard tree inspections resulting in the removal of standing dead, leaning trees, and trees with obvious rot that were within striking distance of targets (people, property, or permanent structures). Since 1994, approximately 575 trees have been removed. Because of time and resource constraints over the past few years, hazard trees have been left on the ground resulting in accumulations of downed wood concentrated in certain portions of the campground.

District employees have expressed concern about increasing pockets of subalpine fir mortality scattered throughout the campground. This is a similar phenomenon that is occurring throughout the region. The mortality is often referred to as "subalpine fir decline or complex" and is attributed to the western balsam bark beetle (*Dryocoetes confuses* Swaine) and Armillaria root disease (causal fungus *Armillaria ostoyae*), either alone or in combination. *Dryocoetes confuses* is closely associated with a phytopathogenic lesion-causing fungus, *Ceratocystis dryocoetidis* Kend. and Moln., which it carries on specialized structures called mycangia located on the beetles thorax

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Introduction

On August 14, 2002 representatives of the Lakewood Service Center visited the [illegible] Ranger District of the Routt National Forest to do a disease, insect, [illegible] in the Teal Lake Campground. The purpose of the visit was to provide [illegible] with regard to management options that could be taken to [illegible] conditions in the campground [illegible]. In attendance were: Jeff Witcosky LSC [illegible], Kelly [illegible] [illegible] Johnson retired LSC Leader, Meg Halford LSC Pathologist [illegible] Westfall Parks Ranger, District Forester. We also [illegible] forest representatives including Carl Maass, Ken [illegible] [illegible] and Mary [illegible].

Teal Lake Campground is adjacent to the southwest corner of the Mount Zirkel Wilderness Area (T7N, R82W, S9). The area is [illegible] composed primarily of lodgepole pine (*Pinus contorta* Dougl. ex Loud.) and [illegible] (*Abies lasiocarpa* (Hook.) Nutt.) with occasional scattered aspen (*Populus tremuloides* Michx.) and Engelmann spruce (*Picea engelmannii* Parry ex Engelm.). The campground area of Teal Lake consists of a [illegible] with about [illegible] acres and the [illegible] with 17 camping units and a group area. The campground is approximately 12 acres in size. The stands within the campground are dominated by lodgepole, with an even-aged stand aged at 80-100 years old (based on stand exam information from nearby stands) (Mark Westfall, personal communication). Historically, stand-replacing fires have occurred at 200 year intervals in the Teal Lake area (Dan Dauglius, personal communication). This fire regime is characterized as a mixed or [illegible] meaning that the current fire regime is within the historic range of variability and the [illegible] including key ecosystem components is low. The last major disturbance at Teal Lake Campground was approximately 80-100 years ago, based on stand age.

Teal Lake Campground was built in 1962. In 1994 the district began removing hazard trees and [illegible] of standing dead [illegible] trees, and trees with visible [illegible] were cut in the campground [illegible] (people, property, or permanent structures). Since 1994, approximately 575 trees have been removed. Because of [illegible] and concern, many over the past few years, hazard trees have been left on the ground resulting in accumulations of downed woody material in certain portions of the campground.

District employees have expressed concern about [illegible] and [illegible] mortality observed throughout the campground. There is a similar phenomenon that is occurring throughout the region. The [illegible] is often referred to as the "lodgepole [illegible] decline or complex" and is attributed to the various lodgepole bark beetle (*Dendroctonus* [illegible]) and Armillaria root disease (*Armillaria ostoyae*) [illegible] either alone or in combination. *Dendroctonus ponderosae* is closely associated with a phytopathogenic [illegible] fungus, *Ceratocystis*, and [illegible] which is carried on [illegible] that is transmitted to the [illegible] during

(Garbutt 1992). The tree often pitches beetle attacks out, but meanwhile the fungus may be successfully introduced into the trees phloem. Fungal lesions develop, weakening trees and increasing susceptibility to subsequent beetle attacks. Coalescing lesions may girdle the tree on their own. In the absence of root disease or some other tree-weakening agent, western balsam bark beetles are seldom a problem. A typical situation is where initially a small pocket of trees are weakened by *Armillaria* and then attacked by beetles. As beetle populations rise, they are able to attack surrounding uninfected trees. The pouch fungus, *Cryptoporus volvatus* (Peck) Shear, commonly colonizes recently dead trees, causing a grayish rot of the sapwood.

Insects and diseases have impacted areas in proximity to Teal Lake Campground over the past several years (see Figure 1). Mountain pine beetle (*Dendroctonus ponderosae* Hopkins) outbreaks occur to the south throughout Troublesome Creek on the Arapahoe-Roosevelt National Forest (ANRF) and in the Green Ridge area of the Routt National Forest. An outbreak area is also present to the north around Independence Mountain on BLM land. A little further away, areas around Lake Granby and along the Williams Fork River (ARNF) have also been heavily impacted. Small patches of scattered mortality occur in proximity to the Teal Lake Campground and throughout the forest. An extensive spruce beetle (*Dendroctonus rufipennis* (Kirby)) outbreak, resulting from the Routt Divide Blowdown of 1997, is just west of the Teal Lake area in the Zirkel Mountains. The 13,000-acre blowdown area has allowed spruce beetle populations to increase so rapidly that entire hillsides of mature spruce within and around the blowdown area have been killed within the last several years. Patches of subalpine fir mortality continue to occur in all spruce-fir forests in the area.

After a walkthrough of the campground we determined that the major forest health issues were subalpine fir mortality caused by Armillaria root disease and/or western balsam bark beetle and lodgepole pine dwarf mistletoe (*Arceuthobium americanum* Nutt. Ex Engelm.). Dwarf mistletoe incidence and severity had increased since Dave Johnson last visited the site in 1997 (See Dave Johnson's Service Trip Report: LSC-97-16). Other insects and diseases that were noted included mountain pine beetle, western gall rust (*Endocronartium harknessii* (J. P. Moore) Y. Hiratsuka), comandra blister rust (*Cronartium comandrae* Peck), and fir broom rust (*Melampsorella ceratsii* (Pers.) Schroet.).

To quantify the overall forest health conditions in Teal Lake Campground an intensive survey was conducted by LSC FHM staff in the fall of 2002. The following report summarizes the findings of that survey and offers management alternatives and recommendations.

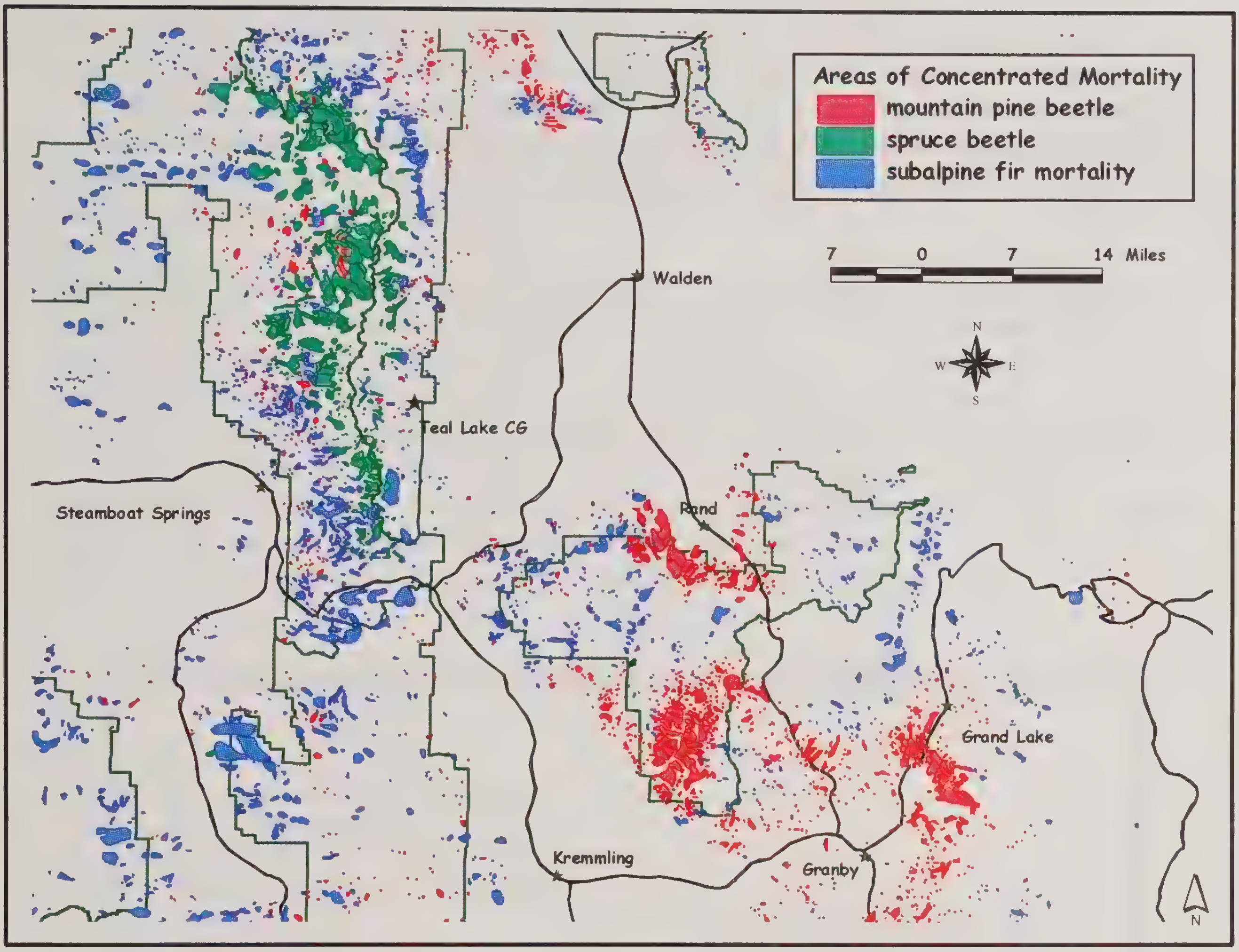

Figure 1. Areas of concentrated mortality attributed to mountain pine beetle, spruce beetle, and subalpine fir complex from aerial survey of the Routt National Forest, 2002.[1]

[1] **Disclaimer**: Due to the nature of aerial surveys, the data on this map will only provide rough estimates of location, intensity and the resulting trend information for any given agent. These data should only be used as an indicator of insect and disease activity, and should be validated on the ground for actual location and casual agent. Shaded areas show locations where trees were killed or defoliated. Intensity of damage is variable and not all trees in shaded areas are dead or defoliated. Many of the most destructive diseases are not represented on this map because these agents are not detectable from aerial surveys. The data represented on this map are available digitally from the USDA Forest Service, R2 FHM.

The cooperators reserve the right to correct, update, modify or replace GIS products. Using this map for purposes other than those for which it was intended may yield inaccurate or misleading results.

Methods

Originally, we intended to do a complete survey of the entire campground and day use area, however, because of limited resources and the dense stand conditions within and around the campground, we were unable to complete this in the allotted time. Instead, we did a combination of a complete survey of the area immediately surrounding campsites and variable radius plots outside of the campground and in areas within the campground without campsites (see Figure 2).

Complete Survey: Data were collected on all trees over 5 inches in diameter at breast height (DBH) that immediately surrounded camping units and permanent structures. Data collected for each tree included: species, DBH, status (live or dead), dwarf mistletoe rating (DMR) (Hawksworth 1977), target and hazard rating (see below), and obvious hazards, defects, insects, or diseases. Because we were particularly interested in identifying pockets of Armillaria root disease, roots of dead trees and stumps were excavated to look for signs of the disease such as rhizomorphs and mycelial fans. We did not excavate roots of living subalpine firs unless they looked like they would die in the very near future, so not all infected trees could be detected with this survey.

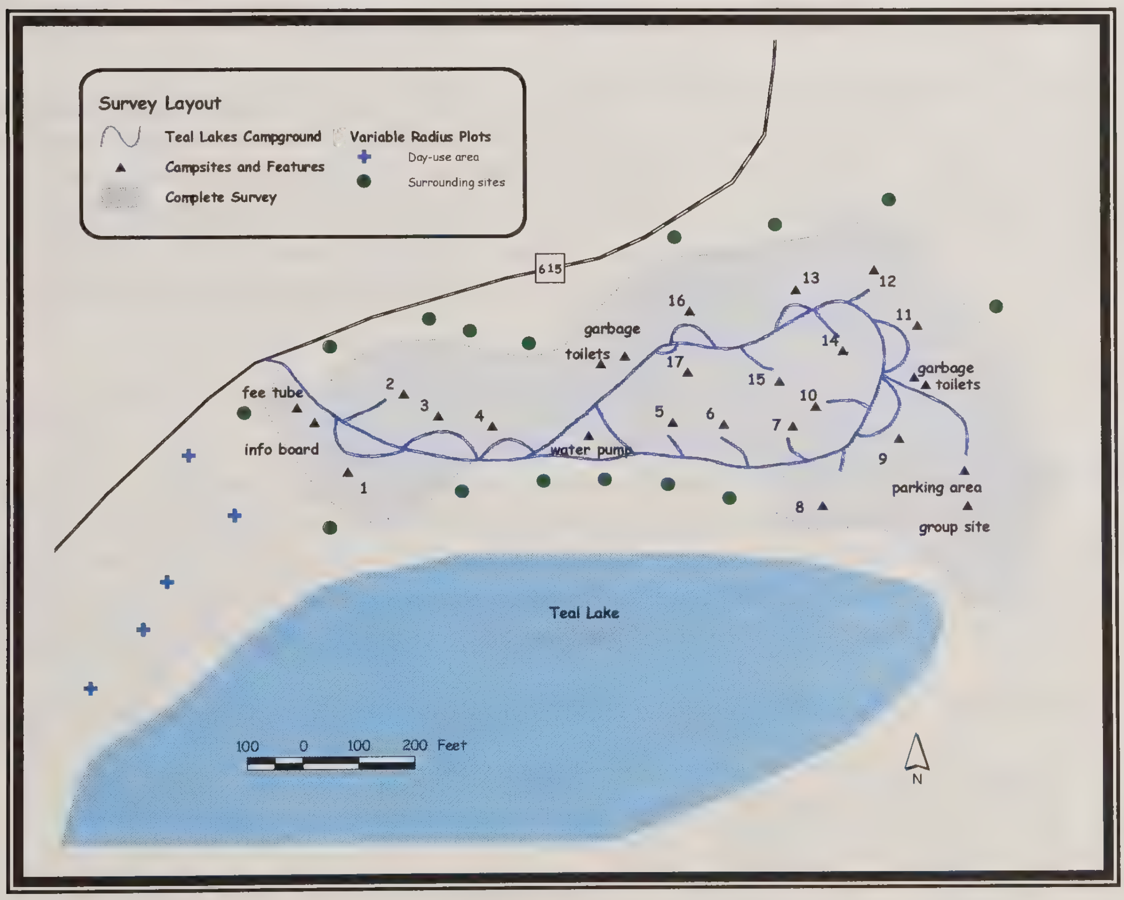

Figure 2. Survey layout of Teal Lake Campground.

[illegible] we intended to do a complete survey of the [illegible] campground and [illegible] however, because of limited resources and the [illegible] of conditions within [illegible] the campground, we were unable to complete this in the allotted time [illegible] a combination of a complete survey of the [illegible] with [illegible] campsites [illegible] radius plots outside of the campground and [illegible] within the [illegible] campsites (see Figure 2).

[illegible] Survey: Data were collected on all trees over 5 inches [illegible] (DBH) [illegible] immediately surrounding [illegible] tents and [illegible] [illegible] each tree including species, DBH, [illegible] mistletoe rating (DMR) (Hawksworth 1977), target, and hazard rating [illegible] insects, or diseases. Because we were particularly [illegible] pockets of Armillaria root disease, roots of dead [illegible] [illegible] the disease [illegible] [illegible] future [illegible] could [illegible]

Each tree was assigned a hazard rating (0-6) based on a modified version of the hazard rating system developed by Johnson (1981). The modified system works as follows: first, the target rating for the tree is determined. Trees within striking distance of people, parking areas, and permanent structures are all rated as a 2. Major trails and roads are assigned a target of 1. Second, defects are determined for the tree. Defects are rated from 0 (no defect) to 3 (highly defective). Then, by multiplying the highest defect (0-3) by the target (1-2) the trees hazard rating is determined. Hazard ratings can be 0, 1, 2, 3, 4, or 6. Managers can then determine what level of risk they are willing to accept. Some important things to keep in mind when using this system are that trees with a hazard rating of three have a high defect (3), but a low target (1). On the other hand, trees with a hazard rating of four have a moderate defect (2) but a high target (2). It is recommended that managers treat at least all trees in hazard class 6.

All trees with a DMR of 4 or greater and/or a hazard rating of 4 or greater were mapped using a GEO Explorer III handheld GPS unit. Stumps with *Armillaria* were mapped as well. The GEO III mapping system proved to be less than ideal because getting really accurate coordinates requires collecting many GPS points per tree, making the process very time consuming. Additionally, the GPS output was not accurate enough for such a detailed mapping project. The result of this is that the map is not accurate enough to navigate back to a particular tree but spatial patterns are accurate enough to determine priority areas for management within the campground.

Variable Radius Plots: Variable radius plots were established approximately 1 chain (66 feet) from the edge of each campsite. Additionally, strip transects were run through the day use area and areas within the campground lacking camping units. Variable radius plots were installed at 3 chain intervals along transects. At each plot a 20 BAF prism was used to determine "in" trees. Data collected included species, DBH, tree status, DMR, and any other obvious hazards, defects, insects, or diseases.

Results and Discussion

Stands in the Teal Lake Campground are composed predominately of lodgepole pine and subalpine fir with lesser components of Engelmann spruce and aspen (see Table 1). Species composition in the day-use area and the area surrounding the campground was similar. Stocking levels are high in the campground area with over 250 trees per acre over 5 inches in diameter and basal areas ranging from 115-180 square feet per acre.

Table 1. Characteristics of live trees in complete survey of Teal Lake Campground.

Species	Number of Trees	Percent	Mean DBH
Lodgepole pine	1911	71 %	8.77
Subalpine fir	729	27 %	7.93
Engelmann spruce	44	2%	8.94
Quaking aspen	22	<1%	6.94

... developed by Johnson (1981). The modified system works ... the target rating for the tree is determined. Trees within striking distance ... and permanent structure are all rated as ... Major ... Second, defects are determined for the tree ... of the defects ... (highly defective) ... then by multiplying the ... the target (1-3) for a hazard rating determined ... Managers ... the hazard rating ... whatever risk they ... things to keep ... using this system ... of three has a high impact (3) but a low target (1) ... rating of ... have a moderate defect (2) but a high target (3) ... figures ... hazard assessment.

Trees with a DBH ... greater ... hazard rating of ... using a GEO Explorer III hand-held GPS unit ... with ... the GEO III ... proved ... because ... coordinate required ... many GPS points ... consuming. Additionally, the GPS ... was not accurate enough ... mapping process. The result of this ... back to a particular tree but spatial ... are accurate enough ... areas for management ... stand.

... Radius Plots: Variable radius plots were established ... in the edges of each campsite. Additionally ... within the ... installed ... to determine ... trees ... were collected ... species ... other obvious hazards, defects, insects or diseases.

... by Teal Lake Campground are composed ... with lesser components of ... in the day-use area and the area surrounding ... Sapling ... inches in diameter and ... ranging from 115 ...

... complete survey of Teal Lake Campground.

Tree hazard ratings indicate that 87% of trees are rated at 3 or below (low to moderate hazard). Thirteen percent of all trees had high hazard ratings, and of these 9% were rated as class 4 and 4% were rated as class 6. Over a third of the high hazard trees (hazard rating 4 or 6) are standing dead. The remaining hazard trees have a combination of defects such as Armillaria root disease and/or western balsam bark beetle; mountain pine beetle, engraver beetles, or spruce beetles; hazardous forks; large wounds; and/or large dead tops or branches. Eleven percent of the high hazard trees were also heavily infested with dwarf mistletoe (DMR class 5 or 6).

The lodgepole pines within the campground are moderately infested with dwarf mistletoe. Three indices can be used to characterize disease distribution (Geils and others 2002). Mean DMR is the average DMR for all host species. The dwarf mistletoe index (DMI) describes the abundance of mistletoe (average DMR) on infected trees only. Finally, incidence is the percentage of host trees infected. There is a direct relationship between these 3 indices: DMR/DMI = Incidence. The mean DMR for all lodgepole pines was 2.7, with an incidence of 77%, and DMI of 3.5. Infection is more severe outside the campground. The average DMR both in plots immediately surrounding the campground and in the day-use area were 3.9 and 3.4 respectively, with DMI's of 4.2 and 4.3 respectively. Any long-term management strategies to reduce mistletoe within the campground will also need to focus on the areas surrounding the campground.

Table 2. Mean DMR, dwarf mistletoe index (DMI), and percent infection (incidence) by unit or reference point in the complete survey.

Unit # or Ref. Point	# of Trees	Mean DMR	DMI	Incidence (%)
1	160	3.1	3.2	98
2	145	3.5	3.5	99
3	113	5.2	5.2	100
4	86	4.4	4.5	98
5	38	3.7	3.9	95
6	50	4.0	4.1	97
7	81	2.6	3.3	80
8	44	2.0	2.7	74
9	103	1.2	3.0	39
10	53	1.9	3.0	63
11	109	0.7	2.7	25
12	101	2.0	2.9	70
13	36	2.5	4.1	61
14	29	0.6	2.8	21
15	44	2.6	3.4	78
16	179	3.3	3.6	93
17	53	3.7	3.8	97
Info. Area	83	2.7	2.8	96
Water Area	15	2.3	2.7	86
East Toilets	121	0.8	2.4	32
West Toilets	83	2.6	2.7	97
Group Area	185	2.6	3.6	73

[illegible] large mistletoe [illegible] of [illegible] were rated [illegible] 3 or below; low [illegible]

3. Thirteen percent of the trees had [illegible] damage, and of these 9% [illegible] and 4% were rated as class 6. Over a third of the [illegible] stand[illegible] 4 or 6) [illegible] dead. The remaining host trees have [illegible] such as Armillaria root disease and/or western [illegible] bark beetle [illegible] pine engraver beetles, or spruce beetles; [illegible] large wound [illegible] or branches. [illegible] percent of the high [illegible] were also [illegible] dwarf mistletoe (DMR class [illegible] 6).

Moderate populations [illegible] are moderately infected with dwarf [illegible] incidence [illegible] (Table 3). Mean DMR [illegible] in the area [illegible] describes the abundance [illegible] ally, incidence [illegible] percentage of host trees infected. There [illegible] these [illegible] incidence. The mean DMR [illegible] was 2.7, [illegible] incidence of 77% [illegible] of 5.5 [illegible] side the campground. The average DMR [illegible] and in the [illegible] were 3.[illegible] respectively [illegible] Any [illegible] will also [illegible] surrounding the campground [illegible]

[illegible] Mean DMR, dwarf mistletoe index (DMI) [illegible] for reference point in the complete survey.

Dwarf mistletoe infections are ubiquitous throughout the campground, however, discrete centers of concentrated severely infected trees (DMR 5 and 6) were identified in units 1-4, unit 6, unit 7, unit 16, and the group area. In some portions of the campground, such as near units 2 and 3, mistletoe-related dieback and mortality are occurring. DMR, DMI, and incidence are summarized by unit or reference point in Table 2. Figure 3 illustrates mean DMR by campsite or reference point. It is important to note that these averages may not reflect the heavily infested pockets. For instance, a campsite may have a concentrated patch of heavily infected trees with light or no infection on most of the other trees, lowering the average.

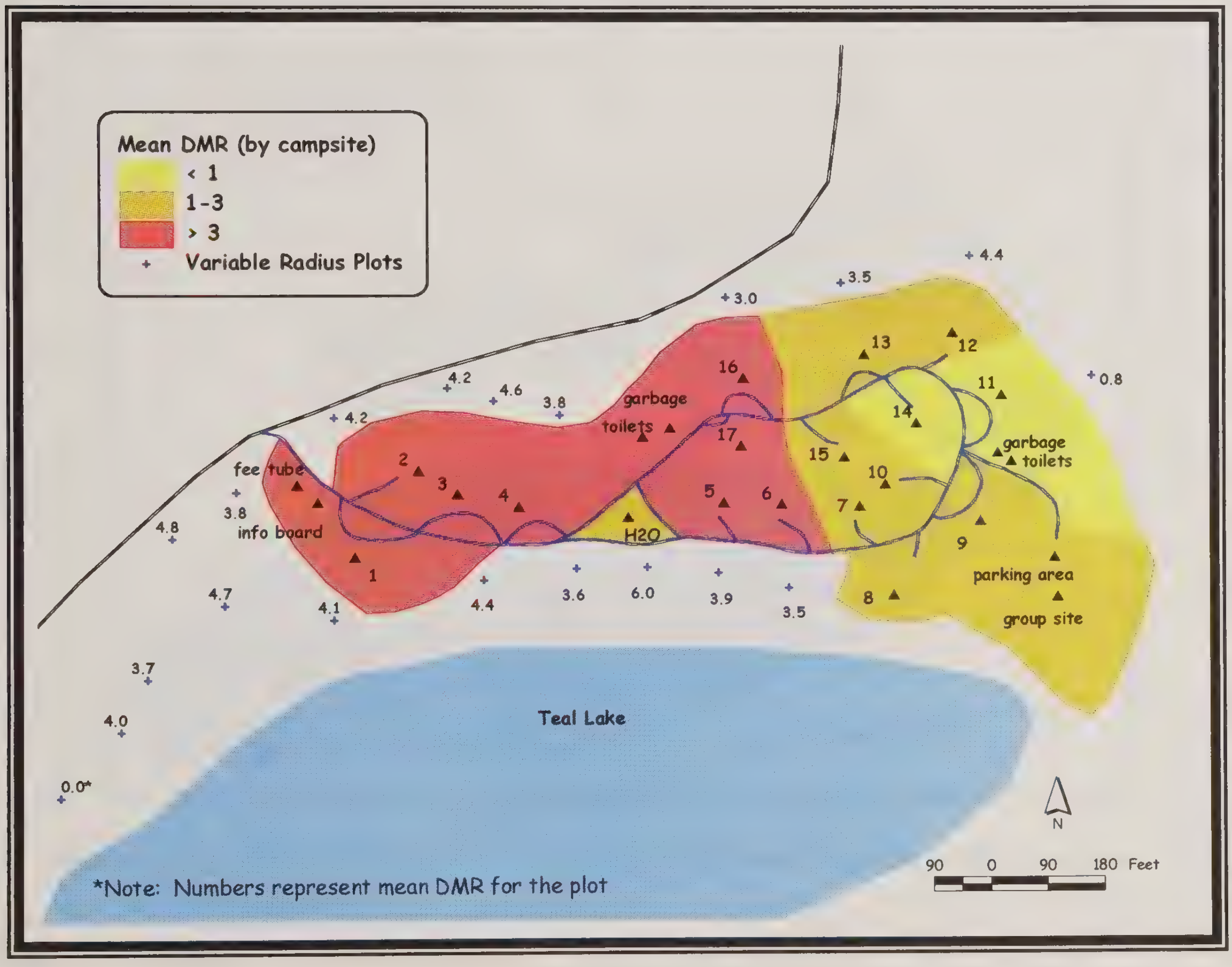

Figure 3. Distribution of dwarf mistletoe in the Teal Lake area.

Subalpine fir mortality and declining subalpine firs were common throughout the campground. It is difficult to precisely quantify this because we did not destructively sample live trees. Of the 109 dead subalpine firs in the complete survey, over half (53%)

[illegible] stand summary [illegible] stand trees (DBH 5 inches) [illegible] in units [illegible] unit 1, unit [illegible]. In some portions of [illegible] units 2 and 7, mainly co-related [illegible] [illegible] are summarized by [illegible] reference point [illegible] Figure [illegible] DMR [illegible] composite of reference points [illegible] not in the [illegible] heavily infested [illegible] instance, a [illegible] infested patch of the [illegible] infested tree, with [illegible] lowering the average.

were either attacked by western balsam bark beetles or were obviously infected with Armillaria root disease.

A map of the distribution of trees and stumps with *Armillaria* illustrates that small pockets of diseased trees and stumps are scattered throughout the campground (see Figure 4). On the ground, these pockets are fairly conspicuous because dead subalpine firs retain bright orange dead needles for several years after dying. *Armillaria* can live as a saprophyte in stumps or dead material for decades infecting healthy trees when their roots come into contact with infected roots.

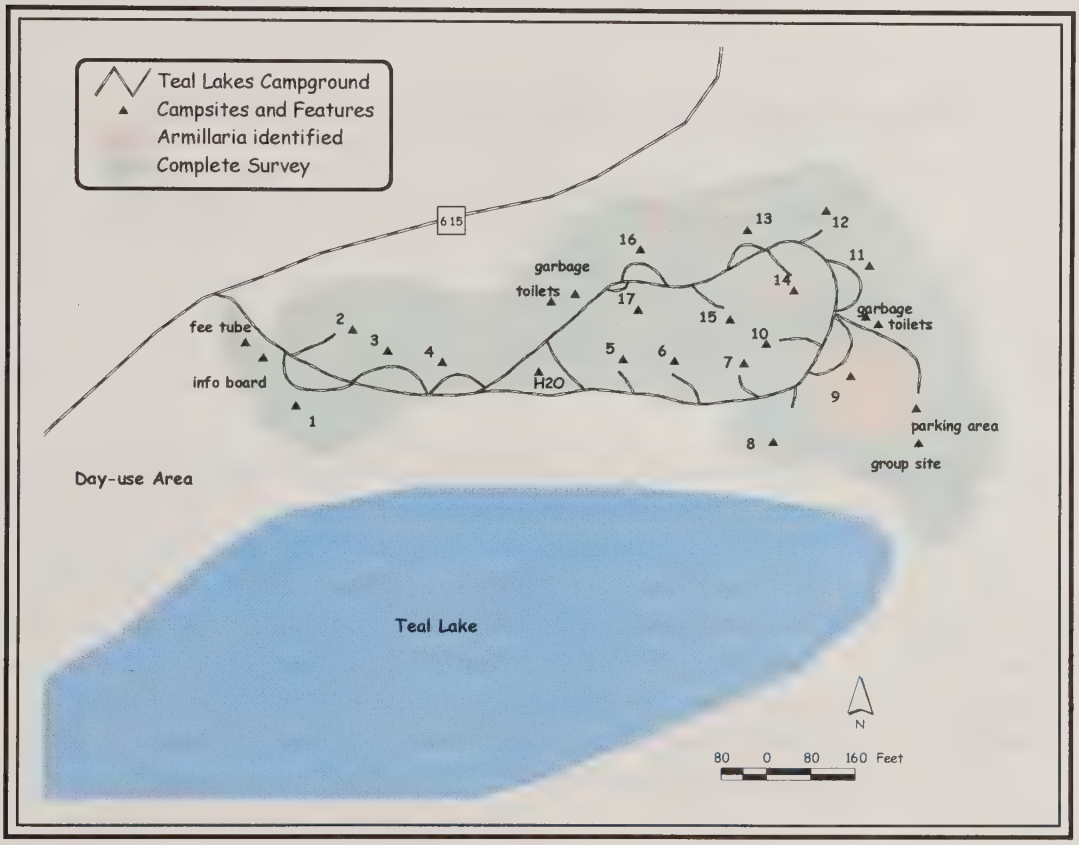

Figure 4. Approximate location of Armillaria root disease pockets in Teal Lake Campground.

There were 11 trees that had been recently attacked by mountain pine beetles (MPB) in the complete survey. Amman and others (1977) developed a risk rating system for classifying stand susceptibility for MPB epidemics based on average DBH, average age, and stand elevation and latitude (see Table 3). Risk factors (1-3) are multiplied to obtain a stand's susceptibility classification (1-9 = low risk, 12-18 = moderate risk, 27 = high risk). Stands in Teal Lake Campground are at high risk for MPB attacks based on elevation, average stand DBH, and estimated stand age. Amman (1978) also noted that stand susceptibility increases with increasing proportion of trees with diameters greater

than 12 inches. Trees are broken into diameter classes in Table 4. Silvicultural treatments should be designed to reduce stand susceptibility. Detailed alternatives and considerations for managing MPB impacts in lodgepole pine stands are provided in Appendix A.

Table 3. Risk rating factors for determining stand susceptibility to MPB.

Elev. at Lat. 40°		Average Age		Average DBH	
<9,000 feet	(3)	> 80	(3)	> 8 inches	(3)
9,000-10,000	(2)	60-80	(2)	7-8 inches	(2)
>10,000	(1)	< 60	(1)	< 7 inches	(1)

Table 4. Size distribution of live lodgepole pines in Teal Lake Campground.

Diameter Class (in)	No. of trees	%
5-7.9	691	36
8-9.9	630	33
10-11.9	367	19
≥ 12	223	12

It is often suggested that trees infected with dwarf mistletoe have thinner phloem and are therefore less susceptible to MPB attacks (Amman 1978, Kulhavey et al. 1978). Furthermore, if and when diseased trees are attacked, surpluses of brood are not produced causing beetle populations to decline. Other researchers have debated this theory. For example, Hawksworth and others (1983) found that trees infected with dwarf mistletoe in Colorado did not have significantly thinner phloem. Regardless of this issue, methods to reduce susceptibility to MPB usually involve reducing stand basal area by thinning and these methods could increase mistletoe levels. An integrated control strategy that incorporates information on the biology of both organisms will be most effective for maintaining high cover over the long term.

Three spruce trees recently attacked by spruce beetles were identified near the information booth at the campground entrance. All 3 trees were still green indicating that attacks occurred this year. Stands most at risk to spruce beetle outbreak are generally in creek bottoms with an average DBH greater than 16 inches, basal area greater than 150 square feet per acre, and a high proportion of spruce in the stand (Holsten and others 1999). Although there is very little spruce in the campground and average diameters are below 16 inches, these trees should be treated before the beetles emerge to prevent beetle populations from building up. The life cycle of the spruce beetle is generally completed in 2 years, however 1-year life cycles have been reported in warmer climates at lower elevations. Treatment strategies to kill the beetles before emergence are the same as for MPB and include salvage and removal, debarking, chipping, burning, burying, or solar treating (see Appendix A).

Other diseases identified included western gall rust, comandra blister rust, and fir broom rust although incidence and severity was minor. These other diseases are generally not indicative of a hazardous situation unless large dead tops result, or brooms are created that can serve as entry courts for other decay fungi. Annual hazard tree inspections would identify such hazards when they occur.

Management Alternatives

Alterative 1: Do Nothing

Under this alternative the number and severity of hazard trees will continue to increase. Dwarf mistletoe will continue to cause slow, progressive decline and mortality of lodgepole pine within the stand. Long-term impacts may be severe as lodgepole pine regeneration becomes more heavily infected. Openings created by the declining overstory will cause uneven-aged conditions to develop, favoring disease spread to young regeneration. The infected regeneration will not provide suitable replacement for the future stand. Stand conditions will continue to provide suitable habitat for increases in mountain pine beetle and other bark beetles. Subalpine fir mortality will continue to increase adding to the hazard tree risk in the campground.

Alternative 2: Reduce Hazard Tree Potential

1) **Develop a hazard tree program and update the vegetation management plan**: The identification and removal of hazard trees in developed recreation sites should be a yearly, planned activity. Additionally, hazard tree inspections and removals should be documented to protect the forest should personal injury or property damage occur. A proper hazard tree inspection program involves identifying hazard trees, inspecting targets, documenting findings, and implementing corrective action. The long-term approach to hazard tree management involves developing vegetation management plans for specific campgrounds and initiating hazard tree inspection programs on a regular basis (every 1-3 years depending on conditions of the area). The vegetation management plan documents current stand conditions, management objectives, stand development goals, current and potential forest health issues that may affect management goals, and alternatives to achieve management objectives. Guidelines and recommendations for developing such programs are available on the Rocky Mountain Region's Forest Health webpage: http://www.fs.fed.us/r2/fhm/ and in the Region 2 Vegetation Management Planning Guide. Forest Health personnel are available to help develop these programs and train field personnel.

2) **Remove hazard trees**: In the short-term, several steps can be taken to mitigate the current hazard tree situation in Teal Lake Campground. Removal of the 106 trees identified in the complete survey as highly hazardous (class 6) should be a priority. After that, the district can determine an acceptable level of risk and

... incidence and severity was [illegible]. These other diseases, etc. [illegible] ... of a hazardous situation unless [illegible] result, or brown [illegible] ... entry courts for root decay fungi. Annual [illegible] ... identify such hazards when they [illegible]

[illegible] Alternatives

[illegible] 1: Do Nothing

[illegible] this alternative the number and [illegible] of hazard [illegible] conditions [illegible] dwarf mistletoe will continue [illegible] progressive [illegible] of [illegible] pole pine within the stand [illegible] long-term impacts [illegible] vegetation becomes more heavily infected. Openings created by the [illegible] will cause uneven-aged conditions to develop [illegible] the infected regeneration will not provide [illegible] stand. Stand conditions will [illegible] to provide suitable habitat for [illegible] the beetle and other [illegible] pine mortality will [illegible] adding to the hazard tree [illegible] in the campground.

[illegible] 2: Reduce Hazard Tree Potential

1) Develop a hazard tree program and update the vegetation management plan. The identification and removal of hazard trees in developed recreation [illegible] should be a yearly planned activity. A [illegible] hazard tree inspections and removals should be [illegible] to protect the forest [illegible] should [illegible] property damage occur. A proper hazard tree inspection program [illegible] identifying hazard trees, inspecting targets, documenting findings, [illegible] implementing corrective actions. The long-term approach to [illegible] management involves developing vegetation management plans [illegible] campgrounds and initiating hazard tree inspection programs [illegible] (every [illegible] 3 years depending on conditions of the area). The [illegible] management plan documents current stand conditions [illegible] stand development goals, current and potential forest health [illegible] management goals and alternatives to achieve management objectives. Guidelines and recommendations for developing such programs [illegible] the Rocky Mountain Region's Forest Health webpage. [illegible] Regional Vegetation Management Planning Guide. Forest Health [illegible] are available [illegible] programs and with field personnel.

[illegible] for the short-term [illegible] can be taken [illegible] [illegible] campground [illegible] [illegible] [illegible] acceptable level [illegible]

remove all trees with hazard ratings greater than the acceptable level. It may be more feasible to remove trees in stages where all of the class 6 trees are removed in the first year and then in subsequent years the rest of the hazardous trees are removed.

Alternative 3: Implement Armillaria Root Disease/Western Balsam Bark Beetle Control:

1) **Reduce subalpine fir mortality**: Little is known about the interactions between silvicultural practices and the incidence of subalpine fir decline. Currently, management strategies to reduce mortality are not known, but susceptibility could be related to density and therefore removing mature subalpine fir during entries is likely to reduce losses. Other practices that may reduce the incidence of subalpine fir decline include encouraging resistant tree species, removing or reducing inoculum, and reducing tree stress by minimizing wounding. Western balsam bark beetle is generally not a problem in the absence of Armillaria root disease so management strategies to control *Armillaria* should also reduce bark beetle levels.

    a) **Remove standing dead and diseased trees**: In the short-term, the removal of obviously diseased trees can alleviate the hazard that these trees create. This approach does not mitigate future disease spread and it is possible that some diseased trees will remain in the stand and pose a hazard because they had no above ground symptoms of root disease. It is very difficult to identify trees infected with *Armillaria* without destructively sampling the root collar and/or roots. Conversely, symptoms of root disease (chlorotic needles, thinning crowns, reduced shoot growth) can be confounded by a variety of other factors such as drought stress, bark beetle attacks, or other pathogens or insect attacks.

    b) **Remove diseased trees and all potential host trees within 30-50 feet**: Armillaria root disease spreads under ground through root contacts between infected and healthy roots. Above ground symptoms of the disease may take years to develop. Because of this, removing host trees within 30-50 feet of the disease margin eliminates the potential hazard of surrounding trees that may be infected as well. In Teal Lake this would involve removing all subalpine fir within 30-50 feet of known disease centers. Although lodgepole pine and Engelmann spruce are hosts of *Armillaria* they should be retained because they are generally considered to be fairly resistant to this pathogen when mature.

    Note: This management strategy is based on the assumption that infections occur in discrete, radially expanding disease centers. On the other hand, some researchers believe that inoculum may be more uniformly dispersed in stands and infection is the result of predisposition or random factors rather than spatial proximity to other diseased trees

with all [illegible] stage infected trees the susceptible level. It may be [illegible] to [illegible] in stage [illegible] where all [illegible] the first year and then in subsequent years the rest of the hardwoods [illegible]

[illegible] 7. [illegible] Armillaria Root Disease/[illegible] Bark Beetle

1) Reduce substrate/host suitability: Little is known about the interaction between silvicultural practices and the incidence of [illegible] in decline. Currently, management strategies to reduce mortality are not known but susceptibility could be related to density [illegible] removing [illegible] subalpine fir during entries is likely to reduce losses. Other practices that may increase the incidence of subalpine fir decline include [illegible]
[illegible] inoculum, [illegible] [illegible] balsam bark beetle is generally not a problem [illegible] Armillaria [illegible] management strategies to control Armillaria should also reduce [illegible] beetle levels

a) Remove standing dead and diseased trees: In the short term, the removal of obviously diseased trees can alleviate the beetle that [illegible] trees. This approach does not mitigate future disease [illegible] is possible that some diseased trees will remain in the stand and may [illegible] because they had no above ground symptoms [illegible] very difficult to identify trees infected with Armillaria [illegible] destructively sampling the root collar and/or roots. Conversely, symptoms of root disease (chlorotic needles, thinning crowns, reduced shoot growth) can be confounded by a variety of other factors such as drought stress, bark beetle attacks, or other pathogens or insect attacks.

b) Remove diseased trees and all potential host trees within 30-50 feet [illegible] Armillaria root disease [illegible] underground through root contacts [illegible] trees infected and healthy roots. Above ground symptoms of the [illegible] may take years to develop. Because of this, removal [illegible] [illegible] of the disease [illegible] the potential hazard of [illegible] may be [illegible] as well [illegible] [illegible] [illegible] 30-50 feet [illegible] [illegible] and [illegible] [illegible]

(James Worrall, personnel communication). If this is the case, disease free buffers would not be an effective control measure.

c) **Reduce tree density to maintain vigorously growing trees**: Improving the growth and vigor of residual trees and reducing tree stress by removing competition may increase resistance to *Armillaria*.

d) **Plant alternative, resistant species in infested areas**: Plant *Armillaria*-resistant species in the understory of infested stands to eventually replace the stand when the overstory is removed or falls apart. Plant species adapted to the site and moisture conditions of the area. This could be done either by conventional planting methods or by transplanting trees from nearby sites with a tree spade. In the Teal Lake area adapted species may include Engelmann spruce and limber pine. Although resistant, aspen is discouraged as a species in recreation sites because it is readily wounded, is very susceptible to insects and diseases, and is prone to failure. Lodgepole pine is fairly susceptible when it is young, but it generally becomes resistant as it grows.

   Note: Transplanting trees will likely require supplemental watering and drought stressed trees will be attractive to minor bark beetles and twig beetles. This method is not recommended in drought years.

e) **Minimize wounding of trees**: Wounding should be minimized during stand entries because wounds cause tree stress and also act as entry points for root pathogens and decay fungi. Residual trees that are severely wounded during harvesting should be removed.

f) **Reduce inoculum by removing stumps**: Because *Armillaria* can persist in stumps for decades, an effective method for reducing inoculum is to physically remove stumps from the site. Although this method has not been used in Region 2, it has been shown to be effective in some high-value sites in the Pacific Northwest. Stump removal is most efficiently accomplished by pushover logging with a bulldozer or large excavator. The stumps can also be mechanically extracted after felling.

Alternative 4: Reduce Stand Susceptibility to Mountain Pine Beetle:

Where MPB populations are at endemic levels, silvicultural strategies to reduce stand susceptibility by thinning stands to below 100 sq. ft. of basal area per acre and reducing the average tree diameter to less than 8 inches may help prevent outbreak populations from building in treated stands (McGregor et al. 1987; Amman 1989). Reducing basal area to between 60 and 80 sq. ft. per acre will increase the length of time that stands are resistant to MPB attack. Stands cut to 60 basal area per acre should remain relatively unsusceptible for about 50 years, those cut to basal area 80 for about 25 – 30 years, and

[illegible] buffers would not be as effective.

c) Reduce tree density to maintain vigorously growing trees. Improving the growth and vigor of residual trees and reducing tree stress by reducing competition may increase resistance to *Armillaria*.

Plant alternative, resistant species in infested areas. Plant *Armillaria* resistant species in the understory in infested areas to eventually replace the stand when the overstory is removed [illegible] adapted to the site and moisture conditions of the area. This could be [illegible] by conventional planting methods or by [illegible] planting trees from nearby sites with a [illegible]. In the East Cascades, [illegible] species may include Engelmann spruce and lodgepole pine. Although [illegible] is discouraged as a species [illegible] because it [illegible] is very susceptible to insects and diseases and is prone to failure. Lodgepole pine is fairly susceptible when it is young, but generally becomes resistant as it grows.

Note: Transplanting trees will likely require supplemental watering and drought stressed trees will be attractive to many bark beetles and [illegible] beetles. This method is not recommended in drought years.

e) Minimize wounding of trees. Wounding should be minimized during stand entries [illegible] entry points for root pathogens and decay fungi. Residual trees that are severely wounded during harvesting should be removed.

f) Reduce inoculum by removing stumps: Because *Armillaria* can persist in [illegible] for decades, an effective method for reducing inoculum is to physically remove stumps from the site. Although this method has not been used in Region 2, it has been shown to be effective on some high-value sites in the Pacific Northwest. Stump removal is most efficiently accomplished by pushover logging with a bulldozer or large excavator. The stumps can also be mechanically extracted after felling.

those cut to 100 for about 11 to 15 years (Schmid and Amman 1992). Maintaining higher basal areas (60 -120 sq. ft. of basal area per acre) may be satisfactory in a campground situation, as long as density is managed frequently as trees grow. Partial cutting lodgepole pine stands presents risk of losing additional trees to windfall and intensifying dwarf mistletoe infection present within the stands. These concerns are addressed in Appendix A and below.

Direct suppression through removal of infested trees as well as making stand conditions less favorable for MPB is necessary to reduce impacts. Cutting, followed by removal or treatment of beetle-infested trees, should be considered a priority before beetles begin emergence in July. Logs can be hauled to sawmills where milling will kill the beetles or to "safe sites" at least one mile away from host trees susceptible to the emerging beetles (Appendix A). If infested logs are left in or near campgrounds, direct suppression of the beetles will be necessary to reduce the threat to uninfested trees in the area. Treatment strategies to kill the beetles before emergence include debarking, chipping, burning, burying, or solar treating. Detailed alternatives and considerations for managing MPB impacts are provided in Appendix A.

Alternative 5: Implement Dwarf Mistletoe Management Program.

Silvicultural Strategies for Dwarf Mistletoe-Infested Stands:

1) **Plant or Favor Non-Host Species:** Plant non-host species in the understory of infested stands to eventually replace the stand when the overstory is removed or falls apart. Plant species adapted to the site and moisture conditions of the area. In lodgepole pine areas some species to plant and/or favor include Engelmann spruce, Douglas-fir, subalpine fir, aspen, bristlecone pine, and limber pine.

2) **Prune Witches' Brooms and Infected Branches:** Pruning is done to reduce dwarf mistletoe spread and improve tree vigor. Pruning is only recommended in high value areas because it is both labor intensive and expensive. Pruning is effective on trees with a DMR less than or equal to 3 as long as infections are concentrated in the lower half of the crown. Prune all live branches in the 2 whorls above the last infected branch while maintaining 50% of the live crown. Trees need to be monitored for latent infections every 3-5 years.

3) **Chemical Controls:** Ethephon is a naturally occurring plant growth regulator that has been used as a chemical control for dwarf mistletoe infested stands. When sprayed on infected trees in the fall, ethephon causes dwarf mistletoe shoots to drop off host trees before seeds are dispersed. This type of treatment may be beneficial in areas where planting non-host species in the understory is not an option. Ethephon does not kill the entire mistletoe plant but it provides short-term protection (1-3 years). Reapplication is necessary until the infected overstory can be removed. Generally, pruning is more economical and effective than ethephon spraying.

a 0.7 ha stand 11 to 15 years old [illegible] Amman 1991 [illegible] minimum heights 60–120 sq. ft. of basal area per acre may be satisfactory [illegible] only as density is managed [illegible] trees grow [illegible] the stands [illegible] additional [illegible] to windfall and intensify mistletoe [illegible] present within the stands. These concerns are addressed in Appendix A and below.

Direct suppression through removal of infected trees as well as [illegible] conditions favorable for [illegible] Cutting, felling, or removal of [illegible] should be considered [illegible] before [illegible] [illegible] be limited to [illegible] site [illegible] susceptible [illegible] (Appendix A) [illegible] Consequently, [illegible] practices will be necessary to reduce the extent of infected trees [illegible] treatment strategies to kill the mistletoe before [illegible] include debarking, girdling, burning, or [illegible] Detailed descriptions and considerations [illegible] are provided in Appendix A.

Alternative 3: Implement Dwarf Mistletoe Management Program

Silvicultural Strategies for Dwarf Mistletoe-Infested Stand

Plant or Favor Non-Host Species: Plant non-host species in the understory of infested stands to eventually replace the stand when the overstory is removed or falls apart. Plant species adapted to the site and moisture conditions of [illegible] In lodgepole pine stands, the species to plant under favor include Engelmann spruce, Douglas-fir, subalpine fir, [illegible], bristlecone pine, and limber pine.

Prune Witches' Brooms and Infected Branches: Pruning is done to reduce dwarf mistletoe spread and improve tree vigor. Pruning is only recommended in high value areas because it is both labor intensive and expensive. Pruning is effective on trees with a DMR less than or equal to 3 as long as infections are concentrated in the lower half of the crown. Prune all live branches in the whorls above the last infected branch while maintaining [illegible] of the live crown. Trees need to be monitored for latent infections every 3–5 years.

[illegible] is a naturally occurring plant growth regulator [illegible] as a chemical [illegible] dwarf mistletoe [illegible] infected trees in the [illegible] dwarf mistletoe [illegible] is not [illegible] type of treatment [illegible] [illegible] and the infected [illegible] and [illegible]

4) **Remove Infected Trees:**

a) **Create Buffer Strips:** Remove all infected trees within 33-50 feet of an area that needs to be protected such as an uninfected stand or an area that has just been treated. Thirty-three feet is the average maximum distance that dwarf mistletoe seeds will spread.

b) **Sanitation Thin:** Sanitation thinning is the removal of all infected overstory and understory trees. A strict sanitation can only be done in lightly infested stands (Stand DMR less than 0.5 = 40 % infection) otherwise the removal of too many trees would leave stands understocked. Generally, thinning is recommended in stands with a DMR less than 3. This is not a true sanitation, but rather an effort to maintain the stand at a lower stand DMR to reduce losses. Opening stands up can reactivate latent dwarf mistletoe infections, so stands need to be monitored every 3-5 years with possible follow-up management.

c) **Even-Aged Management (Harvest and Regenerate the Stand):** Even-aged management, either through clearcutting or shelterwood harvests, is the most effective way to eliminate dwarf mistletoe from heavily infested stands. In order to successfully reduce or eliminate infection and protect regeneration, the area immediately adjacent to the replaced stand must be free of disease, or the area of the replaced stand must be large enough (greater than 20 acres) that infection from edges is insignificant. Boundaries should be placed through natural or manmade openings such as meadows or roads.

d) **Uneven-aged Management (Partial Cutting):** Uneven-aged management is generally not recommended in heavily infested stands because the small units and presence of scattered infected overstory trees leaves stands very susceptible to rapid reinvasion from the overstory to the new regeneration. As a general guideline, small group selection or patch clearcuts should only be used in areas where only 15-25% of trees are infected. To avoid the problems associated with partial harvest systems in heavily infested stands, a cutting cycle of 10-15 years must be used, in which all of the most heavily infested trees (DMR 4-6) are removed during each cycle.

Alternative 6: Combination of Alternatives 2, 3, 4, and 5 or implement an Integrated Forest Health Management Plan.

Implementing a combination of the above listed alternatives will allow the district to achieve forest health goals while addressing specific insect and disease problems.

[illegible]: Removal of infected trees within 30 feet of an [illegible] be protected such as an uninfected stand or an area that [illegible]. Thirty (30) feet is the average maximum distance of dwarf mistletoe seeds will spread.

Sanitation Thin: Sanitation thinning is the removal of all infected overstory and understory trees. A total sanitation can only be done in [illegible] infested stands (Stand DMR less than 0.5 = 40% infection) [illegible] removal of too many trees would leave stands understocked. [illegible], thinning is recommended in stands with a DMR less than 4. [illegible] sanitation, but rather an effort to maintain the [illegible] a lower stand DMR to reduce losses. Opening stands up can reactivate latent dwarf mistletoe infections, so stands need to be monitored every [illegible] years with possible follow-up management.

c) Even-aged Management (Harvest and Regenerate the Stand): Even-aged management either through clearcutting or shelterwood harvests, is the most effective way to eliminate dwarf mistletoe from heavily infected stands. In order to successfully reduce or eliminate infection and protect regeneration, the area immediately adjacent to the replaced stand must be free of disease, or the area of the replaced stand must be large enough (greater than 20 acres) that infection from edges is insignificant. Boundaries should be placed through natural or manmade openings such as meadows or roads.

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Recommendations

- Develop an annual hazard tree inspection program to maintain the safety of the campground.

- Develop (or update) a vegetation management plan to identify goals, pathways, and forest health issues, and ultimately to expedite management of the campground and stands adjacent to the campground.

    - Managed recreation sites represent a significant financial investment and thus vegetation management plans should include an evaluation and assessment of fuels and defensible space. Management actions that maintain defensible space are outlined in the Region 2 Vegetation Management Planning Guide and include:

        - Remove all dead trees and shrubs.

        - Prune branches to a height between eight and ten feet above ground.

        - Where feasible, thin trees to provide 30 feet or more space between crowns.

        - Remove all trees and shrubs within 30 feet of structures.

        - Remove branches or trees within arcing distance of power lines.

        - Remove ladder fuels growing under large trees.

        - Provide at least 10 to 15 feet of separation between islands or groups of trees and shrubs.

        - Trim grasses regularly.

        - Apply appropriate treatments to control weeds such as cheat grass, as they may be more flammable than the vegetation they displace.

        - Maintain developed travel ways as fuel breaks, and trim, thin, or remove encroaching trees and shrubs.

- Remove highly hazardous trees giving priority to all trees with a hazard rating of 6. This includes treating current spruce beetle and mountain pine beetle attacked trees before beetles emerge. For specific guidelines refer to Appendix A.

- Remove all dead and diseased subalpine firs. If at all possible, remove stumps.

- Implement a management program to control Armillaria root disease spread. At this point, the removal of all diseased trees with follow-up management is a reasonable approach. Monitoring of these areas for the next few years will be necessary to track how the disease progresses.

- Reduce tree density to improve growth and vigor of residual trees. Thinning operations should remove all lodgepole pines with DMR class 4-6 and selectively remove mature and weakened subalpine firs. This will have many benefits including reducing mistletoe levels, reducing the risk of bark beetle attack, and reducing susceptibility to root disease.

- Prune witches' brooms on residual trees with a DMR less than or equal to 3.

- Sanitize the understory removing dwarf mistletoe infested regeneration.

- Plant resistant species in the understory for dwarf mistletoe control and root disease control. Engelmann spruce is resistant to both dwarf mistletoe and Armillaria root disease.

- Develop a long-term dwarf mistletoe control program that involves sanitizing surrounding stands and the day-use area with follow-up management in 10 to 15 years to remove the remaining heavily infested trees. At this time the understory will need to be sanitized again as well.

- Apply appropriate treatments in surrounding areas to reduce fire intensities adjacent to the area you want to protect.

- Take advantage of interpretive opportunities to generate public awareness, support, and understanding of the need and benefits of vegetation management activities in recreation areas. We have some excellent posters created by Colorado State Forest Service that cover topics such as mountain pine beetle, spruce beetle, and dwarf mistletoe. These could be displayed in campground or recreation area kiosks as an interpretive tool. Please contact Kelly Sullivan, Pathologist, Lakewood Service Center, kfsullivan@fs.fed.us, if you are interested.

[illegible] surround infected trees with a buffer [illegible] up the infected areas [illegible] approach. A monitoring of these [illegible] the area [illegible] to track how the disease progresses.

[illegible] density to improve growth and vigor [illegible]. Thin [illegible] to remove all lodgepole pines with DMR [illegible] and select [illegible] and associated with [illegible]. This will have many benefits including reducing mistletoe levels, reducing the risk of bark beetle attack and reducing susceptibility to root disease.

- Prune [illegible] brooms on residual trees with a DMR [illegible]

- Sanitize the understory removing dwarf mistletoe infected regeneration.

- Plant resistant species in the understory for dwarf mistletoe control and root disease control. Engelmann spruce is resistant to both dwarf mistletoe and Armillaria root disease.

- Develop a long-term dwarf mistletoe control program that involves sanitizing surrounding stands and the disease area with follow-up management in 10 to 15 years to remove the remaining heavily infected trees [illegible] the understory will need to be sanitized again as well.

- Apply appropriate treatments to surrounding areas to reduce the infestation [illegible] to the area you want to protect.

- Take advantage of interpretive opportunities to increase public awareness and understanding of the need and benefits of vegetation management activities in recreation areas. We have some excellent posters created by Colorado State Forest Service that cover topics such as mountain pine beetle, spruce beetle, and dwarf mistletoe. These could be displayed at campgrounds or [illegible] etc. Kiosks as an interpretive tool. Please contact Kelly Sullivan [illegible] Service Center [illegible] if you are interested.

Literature Cited

Amman, G. D. 1978. Biology, ecology, and causes of outbreaks of the mountain pine beetle in lodgepole pine forests, pp. 39-53. In: Theory and practice of mountain pine beetle management in lodgepole pine forests. Proc. Symp. Washington State University, Pullman, April 25-27, 1978. University of Idaho, Moscow. 224 p.

Amman, G. D. 1978. Biology, ecology, and causes of outbreaks of the mountain pine beetle in lodgepole pine forests, pp. 39-53. In: Theory and practice of mountain pine beetle management in lodgepole pine forests. Proc. Symp. Washington State University, Pullman, April 25-27, 1978. University of Idaho, Moscow. 224 p.

Amman, G. D.; McGregor, M. D.; Cahill, D. B.; Klein, W. H. 1977. Guidelines for reducing losses of lodgepole pine to mountain pine beetles in unmanaged stands in the Rocky Mountains. USDA Forest Service General Technical Report INT-36. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT. 19 p.

Garbutt, R. 1992. Western balsam bark beetle. Forest Pest Leaflet 64. Pacific Forestry Centre, Canadian Forest Service. 4 p.

Geils, B.W.; Tovar, C.; Moody, B. (tech. cords). 2002. Mistletoes of North American Conifers. Gen. Tech. Rep. RMRS-GTR-98. Ogden, UT: USDA, Forest Service, Rocky Mountain Research Station. 123 p.
Online: http://www.fs.fed.us/rm/pubs/rmrs_gtr098.pdf

Hawksworth, F.G. 1977. The 6-class dwarf mistletoe rating system. Gen. Tech. Rep. RM-48. USDA, Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 7 p.

Hawksworth, F.G.; Johnson, D.W. 1989. Biology and management of dwarf mistletoe in lodgepole pine in the Rocky Mountains. General Technical Report RM-169. USDA, Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 38 p.

Holsten, E.H.; Thier, R.W.; Munson, A.S.; Gibson, K.E. 1999. The spruce beetle. USDA Forest Service, Forest Insect & Disease Leaflet 127. 12 p.

Johnson, D.W. 1981. Tree hazards - recognition and reduction in recreation sites. USDA Forest Service, Timber, Forest Pest, and Cooperative Forest Management Technical Report R2-1. 17 p.

McGregor M. D.; Amman, G. D.; Schmitz, R. F.; Oakes, R. D. 1987. Partial cutting lodgepole pine stands to reduce losses to the mountain pine beetle. Canadian Journal of Forest Resources. 17:1234-1239.

Schmid, J. M.; Amman, G. D. 1992. *Dendroctonus* beetles and old growth forests in the Rockies, pp. 51-59. In: Kaufman, M. R.; Moir, W. H.; Basset, R. L. (tech. coord.). Old growth forests in the Southwest and Rocky Mountain regions, proceedings of a workshop. General Technical Report RM-213. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 201 p.

Appendix A

Action Alternatives for Managing Mountain Pine Beetle Impacts*

Management Strategies

Several actions are available to reduce pine mortality due to attack by mountain pine beetle (MPB), *Dendroctonus ponderosae* Hopkins (Order Coleoptera; Family Scolytidae). Indirect action can be taken toward the habitat and host trees required by MPB, while direct action can be taken against the MPB population itself. Currently, there is no way to suppress a large-scale MPB epidemic once it has begun. Prevention should be emphasized where MPB impacts are undesirable. The only long term strategy is to alter stand conditions to be less susceptible to mortality from MPB. Once undesirable MPB-caused mortality has begun, the intent of forest management should be to reduce adverse impacts to affected areas and minimize spread of the problem to adjacent stands. The decision to take a particular action(s) should be based on management objectives, economic factors, MPB population status and trends, stand conditions, location, resource values at risk, and other relevant issues. Consideration of MPB in the context of overall land management is important. Focusing on MPB alone may amplify other problems, such as dwarf mistletoe infestation (Hawksworth and Johnson 1989). A combination of the following action alternatives may be useful in most situations for minimizing MPB attacks.

Alternative 1: Do Nothing

Accept pine mortality and associated impacts caused by MPB as a natural phenomenon. MPB is a native insect that has been active for thousands of years. It is one of the most important biotic causes of pine mortality in conifer forests across the West (Amman et. al. 1989). MPB populations increase and decrease without direct human influence. Epidemics of MPB have many ramifications in addition to the creation of dead pine trees. These impacts vary depending upon the extent, intensity, and duration of the MPB epidemic.

> <u>Where to use</u> - Use where other alternative actions are not desired, cannot be implemented or will not be effective. One example would be designated wilderness areas.
>
> <u>Advantages</u> - No mechanical site disturbance or introduction of foreign materials into the environment will occur. Understory vegetation may prosper. From extensive and intense MPB epidemics, water yield and possibly annual stream flow will increase (McGregor and Cole 1985). Tree regeneration may be facilitated by increased sunlight reaching the forest floor. Changes in vegetation and cover may be advantageous to certain wildlife species, particularly those that utilize dead trees. Successional trends may benefit management objectives.

Public sentiment might be positively impacted by the decision to "let nature take its course." Resources could be redirected to managing uninfested stands to minimize future MPB impacts.

Disadvantages - The "do nothing" alternative means human activity will not change a stand's resistance to MPB population increase and spread. Dead trees can become safety hazards over time as they rot and fall. Timber values are reduced or lost. MPB epidemics may adversely affected visual quality by large numbers of dead and dying trees. The presence of fallen trees may affect travel within affected stands. Fire hazard will be increased during the period when dry needles are present on recently killed pines and there will be increased heavy fuel buildup after dead trees fall to the ground (Cole and Amman 1980). Regeneration may be inhibited due to loss of seed source, the covering effect of dead fallen trees, and lack of seedbed preparation. Changes in vegetation and cover may not be advantageous to certain wildlife species. Successional trends may not meet management objectives. Public sentiment may be negatively impacted, even in situations where a MPB epidemic cannot be stopped by direct action.

Alternative 2: Silvicultural Treatment

Actions that promote tree vigor and wide spacing are the primary means to reduce or prevent the impact of MPB epidemics (Amman 1989). The most recommended long-term tactic to minimize losses to MPB is to partially cut susceptible stands or harvest and subsequently replace susceptible stands. Removal of individual pines of low vigor and poor health will lessen the chance of a MPB outbreak. Lodgepole pine stands at high risk to MPB are those at lower elevation-latitudes where average tree diameter exceeds 8 inches and average tree age exceeds 80 years (Amman and others 1977). Favorable conditions for MPB in ponderosa pine stands are those where average tree diameter is greater or equal to than 8 inches and basal area is greater than or equal to 120 square feet (Schmid and Mata 1992). Partial cutting that reduces stands to 60 - 80 square feet of basal area or less and average tree diameter to below 8 inches reduces stand susceptibility to MPB. When partially cutting susceptible stands, care must be taken to avoid leaving dense pockets of mature pines, because these areas can serve as foci for MPB attack (McGregor et. al. 1987).

The risk of windfall must also be considered when partially cutting lodgepole pine stands. Soil depth and stand density contribute to windfirmness as does stand exposure. Alexander (1972) describes windfall risk based on exposure as follows:

Visibility [illegible] might [illegible] positively impacted by the density [illegible] the [illegible] its crowns. Resources could be redirected to managing unharvested stand [illegible] future MPB happens.

Livestock [illegible] - The "no action" alternative means human activity will [illegible] change [illegible] stand [illegible] to MPB population increase and [illegible]. Dead trees can become safety hazards over time as they [illegible] and fall. [illegible] reduced or lost. MPB epidemics may adversely affected [illegible] numbers of dead and dying trees. The presence of fallen trees [illegible] within affected [illegible] hazard will be increased during the period when needles [illegible] present on recently killed pines and there will be increased [illegible] until [illegible] dead trees fall to the ground (Cole and Amman 1980). Resources may be [illegible] due to loss of seed source, the occurrence of dead fallen trees, and lack of seedbed preparation. Changes in vegetation and cover may be advantageous to certain wildlife species. Successional conditions may not meet management objectives. [illegible] may be negatively impacted even in situations where a MPB epidemic [illegible] stopped by direct action.

Alternative 2 Silvicultural Treatment

[illegible] that promote tree vigor and wide spacing are the primary [illegible] the impact of MPB epidemics (Amman 1989). The [illegible] [illegible] to minimize losses to MPB is to partially cut susceptible stands or [illegible] [illegible] susceptible stands. Removal of individual pines of low [illegible] [illegible] will lessen the chance of a MPB outbreak. Lodgepole pine stands [illegible] high risk [illegible] those at lower elevation-latitudes where average tree diameter exceeds 8 [illegible] and average tree age exceeds 80 years (Amman and others 1977). Favorable [illegible] for MPB in ponderosa pine stands are those where average tree diameter is [illegible] equal to than 8 inches and basal area is greater than or equal to 120 square feet [illegible] and Mata 1992). Partial cutting that reduces stand [illegible] to 60 - 80 square feet of [illegible] or less and average tree diameter to below 8 inches reduces stand susceptibility. When partially cutting susceptible stands, care must be taken to avoid leaving [illegible] pockets of mature pines, because these areas can serve as foci for MPB attack [illegible] et al. 1989).

[illegible] of when partial cutting lodgepole pine stands, [illegible] to windfirmness [illegible] stand exposure, [illegible] based on [illegible] as follows:

Low Windfall Risk Situations

1. Valley bottoms except where parallel to prevailing winds and all flat areas.
2. All lower and gentle middle north and east facing slopes.
3. All lower gentle middle south and west facing slopes that are protected by considerably higher ground not far to windward.

Moderate Windfall Risk Situations

1. Valley bottoms parallel to the direction of prevailing winds.
2. All lower and gentle middle south and west facing slopes not protected to the windward direction.
3. Moderate to steep middle and all upper north and east facing slopes.
4. Moderate to steep middle south and west facing slopes protected by considerable higher ground not far to windward.

High Windfall Risk Situations

1. Ridgetops.
2. Moderate to steep middle south and west facing slopes not protected to the windward, and all upper south and west facing slopes.
3. Saddles on ridgetops.

Windfall risk is increased in the above situations by poor drainage, shallow soil and defective roots and boles

Acceptible partial cutting methods that are recommended to reduce a stand's risk to MPB include commercial thinning, shelterwood cutting, and overstory removal. Seed tree cuts can work with ponderosa pine but should not be considered for lodgepole pine stands due to the likelihood of windfall. In stands that are lightly infested with MPB, all trees that are attacked may be removed along with the most susceptible trees (generally the larger diameter lodgepole pines or mature ponderosa pine that occur in dense clumps) without exceeding standard basal area prescriptions. Heavily infested stands can be addressed with greater partial cuts in ponderosa pine but are generally not advised in lodgepole pine stands because of windthrow problems.

Clearcutting is also a useful tool to create conditions favorable to regenerating lodgepole pine and converting mature stands to younger stands. Block or patch cutting within extensive areas of pure even aged stands of lodgepole pine can reduce the potential for MPB epidemics, by reducing the area likely to be infested at one time. Also clearcutting is generally preferable to partial cutting in lodgepole stands that are understocked or heavily infested by dwarf mistletoe (Alexander 1974). Partial cutting is not recommended where the stand dwarf mistletoe rating is above 3 (Hawksworth and Johnson 1989).

Where to use – Partial cutting is a preventive treatment that addresses long-term tree and stand health. It should be incorporated into land management activity wherever MPB impacts are considered undesirable or are to be minimized. It is particularly important where timber values are the highest priority.

Advantages - Silvicultural treatment reduces the susceptibility of trees to MPB attack and has been shown to limit pine mortality from MPB in forest stands (Amman and others 1977). While this alternative does not guarantee immunity from MPB infestation, it promotes tree vigor and creates conditions known to be less favorable to MPB. Cutting green trees prior to MPB infestation maximizes economic return from timber resources, because MPB-killed trees are usually less valuable. If applied on a landscape scale, silvicultural treatments could result in a mosaic of stand susceptibility to MPB, which may reduce the development of large-scale MPB epidemics. Silvicultural treatments may allow managers to manipulate the landscape to fit management objectives better than natural processes such as MPB epidemics or stand replacing fires.

Disadvantages - This action is not suitable for areas where tree cutting is undesirable, unaffordable or not allowed. Examples of such areas are wilderness, steep slopes, and where the visual quality of cut areas would be less than that of dead trees. It is not possible in areas with no logging industry.

Alternative 3: Sanitation and Salvage Harvesting

Sanitation harvesting is a treatment applied to currently infested pine stands. Green trees with immature MPB developing under the bark are cut and removed to an area at least one mile from susceptible pines or processed at a mill prior to MPB emergence. Sanitation must be completed prior to July when MPB emerges to be effective. Salvage harvesting is cutting pines already killed by MPB after beetle emergence. Salvage does not reduce MPB populations but is commonly done in conjunction with sanitation.

Where to use - Stands that are currently under attack where reduction of the MPB population and recovery of timber resource values is desirable and where timber harvesting activity is acceptable. Especially appropriate are infested stands in proximity to uninfested, susceptible high value stands where mortality from MPB would threaten land management objectives. Sanitation could also be used concurrently with silvicultural treatment in stands where the MPB population has not yet reached epidemic levels.

Advantages - MPB populations can be significantly reduced by removing most or all infested trees prior to the emergence of the next generation of beetles. Sanitation provides a degree of protection to surrounding, uninfested trees and stands by removing a nearby source of attacking beetles. Timber volume could be recovered that would otherwise be lost. Initial increased fire potential from dead trees holding dry needles is reduced and future fire danger from heavy fuels

[illegible] using [illegible] removal cutting [illegible] preventive treatment that addresses [illegible] long-term [illegible] health. It should be incorporated into land management [illegible] activity [illegible] of MPB in parts are considered undesirable or are to be [illegible] minimized. [illegible] particularly important where timber [illegible] are the highest priority.

Advantages - Silvicultural treatment reduces the susceptibility of [illegible] attack and has been shown to [illegible] mortality from MPB in [illegible] (Amman and others [illegible] 7). While this alternative does not prevent [illegible] from MPB infestation, it promotes tree vigor and [illegible] less [illegible] vulnerable to MPB. [illegible] during growth [illegible] prior to [illegible] infestation [illegible] economic return from timber resources because MPB-killed [illegible] value. [illegible] applied on a landscape scale, silviculture treatments [illegible] [illegible] stand susceptibility to MPB, which may reduce [illegible] large-scale MPB epidemics. Silvicultural treatments may allow [illegible] manipulate the landscape to fit management objectives better than [illegible] processes such as MPB epidemics or [illegible] replacement.

Disadvantages - This option is not suitable for areas [illegible] cutting is undesirable, unaffordable or not allowed. Examples of such areas [illegible] wilderness, steep slopes, and where the visual quality [illegible] would be [illegible] lead time. It is not possible in areas [illegible] the beginning [illegible] history.

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[illegible] infested trees [illegible] protection to surrounding uninfested trees and [illegible]

[illegible]

created by dead and down trees is also reduced. The visual impact of dead and dying trees is reduced. The hazard from falling trees is lowered. Pine regeneration will be encouraged by both the site disturbance and the reduction in shade.

Disadvantages - There is little time for implementation of sanitation because infested trees must be removed before MPB emergence. Sanitation/salvage harvesting has not been demonstrated to suppress MPB populations on a scale larger than the individual stand, although this may occur in some cases. It should not be considered an efficacious control tactic across large landscapes or during severe MPB epidemics where MPB immigration into treated stands is likely. Sanitation/salvage harvesting undertaken without additional considerations for stand health and survival can lead to residual conditions that have other significant problems, such as increased spread and intensification of dwarf mistletoe (McGregor and Cole 1985). Tree removal may not be aesthetically acceptable in some areas. Adverse site and soil disturbance may occur.

Alternative 4: Infested Tree Treatment

Cut and individually treat infested pines prior to the maturation and emergence of MPB brood. Any action that kills most or all of the MPB within infested trees prior to MPB emergence falls under this direct control action alternative. **The following examples do not work in all situations and are not all supported by rigorous research results.** Examples of infested tree treatment techniques are as follows: (1) Cut and burn on site; (2) Cut and bury at least 6 inches deep on site; (3) Cut and chip; (4) Cut and remove the bark from infested portions of logs before the immature MPB transform to adult beetles; (5) Cut and expose to direct sunlight such that the trunk surface receives sufficient heat to kill the beetles under the bark, rotating the trunk to ensure complete exposure (Negron et. al. 2001); (6) Cut and cover with thick clear plastic such that the trunk surface receives sufficient heat to kill the beetles under the bark (Negron et. al. 2001); It is important to check any treatment near the end of June before adult beetle emergence. Infested tree treatments differs from sanitation harvesting (Alternative 3) because it is usually applied on a smaller scale and is often not conducted in conjunction with salvage harvesting.

Where to use - This alternative is most appropriate for treating small spots in areas of great concern, such as those adjacent to residences and within developed recreation sites. It may also be appropriate in unroaded areas, on slopes too steep to harvest with conventional methods, in areas where the disturbance from conventional harvest activity is unacceptable, and in areas where there is no possibility of sanitation/salvage harvesting due to insufficient volume, no bids or other reasons.

Advantages - Much of the immature MPB population can be eliminated from the treated area. As a result of infested tree treatment, risk to surrounding uninfested trees is reduced by removing a nearby source of attacking beetles. This

alternative may also provide time for silvicultural treatment to be implemented. The fire hazard from the presence of dead pines retaining dry needles is lowered. The visual impact of dead and dying trees is reduced. The subsequent hazard from falling trees is lowered. Pine regeneration may be encouraged by the reduction of shade. Firewood may be recovered from this treatment.

Disadvantages - There is little time for implementation, because the developing MPB brood must be destroyed before the next emergence period in July. Localized beetle populations can be suppressed by this action, but it rarely reduces a stand's susceptibility to MPB attack. Additional follow-up treatments may be needed in subsequent years because it can be difficult to locate and treat all infested trees in an area. Infested trees may be inadvertently moved as firewood prior to MPB emergence, possibly spreading the infestation.

Alternative 5: Protection of High Value Trees

Prior to the attack period of MPB, boles of green, uninfested, high value trees may be sprayed with a labeled insecticide that kills attacking MPB to prevent infestation.

Where to use - This action is appropriate for high value individual trees such as found in developed recreation sites when there is a threat from active MPB populations in the vicinity. Because specialized equipment may be required, trees must be relatively accessible. This action is not effective for trees that are already infested by MPB.

Advantages - Controlled experiments and operational experiences have established this action as very effective in protecting individual pines from infestation. Specific formulations of carbaryl and permethrin are currently labeled for this use. Protection using carbaryl has been demonstrated to last from 10 - 18 months, meaning that a late spring application may afford two years of protection (Hastings and others 2001).

Disadvantages - Carbaryl and permethrin are toxic to insects other than MPB. Insecticide applied as protection does not effectively reduce the beetle population or address stand susceptibility to future MPB outbreaks. It does not guarantee absolute protection, especially if the application is not thorough and complete. Insecticide treatment can be very expensive, especially if large areas require treatment. Potential environmental hazards exist from improper use, storage or disposal of chemicals and chemically treated wood. There may be a shortage of qualified pesticide applicators. Many citizens have concerns about environmental contamination and safety.

[illegible] may also provide some [illegible] treatment in the [illegible] the fire hazard from the presence of dead pines retaining dry needles is low. The visual impact of dead and dying trees is reduced. The subsequent [illegible] from falling trees is lowered. Pine regeneration may be encouraged by the reduction of shade. Firewood may be recovered from this treatment.

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Literature cited

Alexander, R. R. 1972. Partial cutting practices in old-growth lodgepole pine. Research Paper RM-92. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 16 p.

Alexander, R. R. 1974. Silviculture of central and southern Rocky Mountain forests: A summary of the status of our knowledge by timber types. Research Paper RM 120. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. Fort Collins, CO. 36 p.

Amman, G. D. 1989. Why partial cutting in lodgepole pine stands reduces losses to mountain pine beetle: Proceedings – symposium on the management of lodgepole pine to minimize losses to the mountain pine beetle. General Technical Report INT-262. USDA Forest Service, Intermountain Research Station. Ogden, UT. 48-59.

Amman, G. D.; McGregor M. D.; Dolph, R. E. Jr. 1989. Mountain pine beetle. USDA Forest Service Leaflet 2. USDA Forest Service, Washington, DC. 11 p.

Amman, G. D.; McGregor M. D.;Cahill, D. B.; Klein, W. H. 1977. Guidelines for reducing losses of lodgepole pine to mountain pine beetles in unmanaged stands in the Rocky Mountains. General Technical Report INT-36. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT. 19 p.

Cole, W. E.; Amman, G. D. 1980. Mountain pine beetle dynamics in Lodgepole pine forests. Part 1: Course of an infestation. General Technical Report INT-89. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT. 56 p.

Hastings, F. L.; Holsten, E. H.; Shea, P. J.; Werner, R. A. 2001. Carbaryl: a review of its use against bark beetles in coniferous forests of North America. Environmental Entomology Vol. 30: 803-810.

Hawksworth, F.G.; Johnson, D.W. 1989. Biology and management of dwarf mistletoe in lodgepole pine in the Rocky Mountains. General Technical Report RM-169 Fort Collins, CO: USDA, Forest Service, Rocky Mountain Forest and Range Experiment Station. 38 p.

McGregor, M. D.; Cole D. M. 1985. Integrating management strategies for the mountain pine beetle with multiple resource management of lodgepole pine forests. General Technical Report INT-174. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT. 68 p.

McGregor M. D.; Amman, G. D.; Schmitz, R. F.; Oakes, R. D. 1987. Partial

cutting lodgepole pine stands to reduce losses to the mountain pine beetle. Canadian Journal of Forest Resources. 17:1234-1239.

Negron, J. F.; Shepperd W. D.; Mata, S. A.; Popp, J. B.; Asherin, L. A.; Schoettle, A. W.; Schmid, J. M.; Leatherman, D. A. 2001. Solar treatments for reducing survival of mountain pine beetle in infested ponderosa and lodgepole pine logs. USDA Forest Service Rocky Mountain Research Station Research Paper RMRS-RP-30. 11p.

Schmid, J. M.; Mata, S. A. 1992. Stand density and mountain pine beetle caused tree mortality in ponderosa pine stands. Research Note RM-521. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. Fort Collins, CO. 4 p.

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